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BELIZE
Market Price Monitoring Systems Assessment

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About the World Food Programme

Reaching nearly 150 million people in over 120 countries each year, the World Food Programme is the world's largest humanitarian organization saving lives in emergencies and using food assistance to build a pathway to peace, stability and prosperity, for people recovering from conflict, disasters and the impact of climate change.

WFP Caribbean works with national, regional and international partners to strengthen the region's resilience to the climate crisis, and other risks. WFP adopts a systems- focused approach as part of its capacity strengthening efforts through research and advocacy, digitalization, human resource development, south-south cooperation, and by investing in critical infrastructure and assets. WFP works with partners to provide direct assistance to populations impacted by shocks when events surpass national and regional capacities.

These investments place the most vulnerable people at the centre of efforts to minimize the combined impacts of climate, economic and other shocks on the Caribbean. WFP Caribbean's multi-country strategic plan[1] supports 22 countries and territories across the English- and Dutch-speaking Caribbean through leveraging its expertise in vulnerability analysis and mapping; end-to-end supply chain management; shock-responsive social protection; food systems strengthening and climate risk financing

[1] https://executiveboard.wfp.org/document_download/WFP-0000135918?_ga=2.66316206.168143545.1679498584-1123234837.1677265273

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List of Acronyms

API	Application Programming Interface
ASCYUDA	Automated System for Customs Data
BAIMS	Belize Agricultural Information Management System
BBS	Belize Bureau of Standards
BCED	Belize Customs & Excise Department
BMDC	Belize Marketing & Development Corporation of MAFSE
CPI	Consumer Price Index
FAO	Food & Agriculture Organization of the United Nations
FD-ID	Final-Demand Intermediate-Demand (price index)
MAFSE	Belize Ministry of Agriculture, Food-Security, & Enterprise
MIOA	Market Information Organization of the Americas
SIB	Statistical Institute of Belize
PPI	Producer Price Index
PPSIU	Policy & Public-Private Sector Interface Unit of MAFSE
UN	United Nations
UNCTAD	United Nations Capital Trade and Development Fund
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
USDA	United States Department of Agriculture
WFP	World Food Programme

Executive Summary

Rising global food and energy prices have hampered the ability of people to meet their everyday needs. As part of a UN Joint SDG Fund Joint Programme to support Belize and other Caribbean nations with the cost-of-living crisis, the United Nations World Food Programme (WFP) has partnered with the Government of Belize to map and outline their market monitoring processes, with a view towards harmonizing efforts across the different units currently responsible and contributing towards a single best-in-class system for the country. Such a system should provide timely market information across entire value chains for critical agri-food commodities, from farm to fork, and disseminated at a global scale. This information is important for several reasons including early warning and forecasting, policy tools such as price controls and subsidies that are implementable by the government, attracting foreign and domestic investment, measuring current economic patterns and impact of current policies, and calibrating subsidies and assistance programs for vulnerable populations.

The mapping exercise identified four main institutions within the government that are collecting market information—the Statistical Institute of Belize (SIB), Ministry of Agriculture, Food-Security, and Enterprise (MAFSE), Belize Customs and Excise Department (BCED), and the Belize Marketing Development Corporation (BMDC). MAFSE and SIB operate the two largest market surveillance operations and have built world-class teams and systems for differing missions. MAFSE's focus is on agricultural surveillance, while SIB focuses on retail price data collection for computing the consumer price index (CPI). The most critical information gaps in SIB's CPI protocol are in fact covered by MAFSE, and vice versa. Hence, MAFSE and SIB naturally complement each other, but the fact that they are designed for different purposes hinders achieving large-scale synergies.

The government can benefit from harmonizing the market monitoring efforts of SIB and MAFSE, with a coordinating authority appointed for all market monitoring efforts throughout the government. For several reasons SIB is a natural choice for this function. They have technical proficiency and a unique bird's-eye-view over all data gathering systems the government has at its disposal. More fundamentally, SIB has built a world-class data-collection tool combined with a unique operating model that achieves increasing returns to scale. Hence, SIB can potentially deliver market data at a lower unit cost than any other entity within the government. The report recommends SIB incorporates MAFSE's current market monitoring into their efforts and enable MAFSE to focus their current surveillance systems towards defining agri-input schedules, collecting harvesting and post-harvest costs, and finally farmgate and wholesale prices. With these changes in place, the government should have the necessary data to understand price transmission and cost structure across several major agri-food commodity value chains.

Finally, several technological and technical improvements are identified, including application programming interfaces (APIs) for the CPI and agricultural surveillance systems and calculating highly informative final-demand intermediate-demand (FD-ID) indices. FD-ID price indices aggregate

prices of goods and services in an integrated manner, dividing demand into stages of final demand and various stages of intermediate demand, making it possible to track the process of price transmission across goods and services while avoiding the double-counting of inputs.

1. Background and Objectives

A global cost of living crisis that unfolded in 2022, brought on by the fiscal and inflationary shocks created first by COVID-19 and subsequent global supply-chain constraints – particularly with respect to food and energy. These shocks impact how people in Belize and beyond are able to put food on the table in Belize. The August 2022 Caribbean Community (CARICOM) and World Food Programme (WFP) jointly implemented Regional Food Security and Livelihoods survey found two-thirds of respondents reported skipping meals/eating less, eating less preferred foods, or going an entire day without eating in the week leading up to the survey, mirroring results from February 2021 (World Food Programme & CARICOM, 2022).

As part of broader effort to address the cost-of-living crisis, United Nations (UN) agencies—World Food Programme (WFP), Food and Agriculture Organization (FAO), UN Educational, Scientific, and Cultural Organization (UNESCO), and UN Children's Fund (UNICEF)—are working closely with the government of Belize to implement a Joint Programme focused on *Strengthening Belize's Evidence Base for Crisis Response*. This is part of an initiative of the UN Joint Sustainable Development Goals (SDG) Fund to address the impacts of the cost-of-living crisis. This crisis has particularly affected the Caribbean region due to its heavy reliance on food imports and weak linkages across local value chains.

As part of this joint programme, WFP is working with the government to identify ways to strengthen the evidence base with respect to food security impacts and to inform the design of appropriate and timely strategies to support populations affected by current crisis and future shocks. This includes:

1. Mapping the price and supply-chain information systems (referred to as market monitoring systems) for agri-food commodities that the Government has at its disposal.[2]
2. Quantitative and qualitative research to understand how the crisis is affecting the population, with a strong focus on the most vulnerable groups and sectors in Belize.
3. Providing policy recommendations to strengthen the government market information and other systems to identify and inform responses to shocks, including through the design of tools and technical assistance.

These efforts are part of WFP's broader commitment to the government to strengthen food systems and social protection systems, which are critical for promoting food security and ensuring that people are able to meet their needs when shocks occur.

1.1 OBJECTIVE OF THIS REPORT

This report specifically focuses on the component regarding market monitoring systems for agri-food commodities. It explores the following questions:

- What are market monitoring systems? Why are they important especially with respect to the activities of the Government of Belize?

[2] *Agri-food* refers to food produced as a result of agriculture.

- What market monitoring systems are available to the government?
- How do the most prominent market monitoring systems in the government work? What tools do they use? What are their strengths and weaknesses?
- What are the existing gaps in government systems? How can these gaps be mitigated through specific policy and tools?

Based on the research conducted, this report aims to provide the reader with a clear end-to-end mapping of the primary market monitoring systems undertaken by the Government of Belize, a thorough understanding of what gaps are present and opportunities for improvements. Recommendations are provided on how to strengthen processes and maximize their value. These recommendations are intended to stimulate discussion on options and paths forward to develop a roadmap for creating a best-in-class Belizean market monitoring system and the advantages that these would offer for both the government and the population at large.

1.2 SCOPE & LIMITATIONS

This report considers market monitoring systems in its most expansive definition possible. This approach was taken owing to the size of Belize, tight government-business collabouration, and high sophistication both in responsibilities and technical capacity of MAFSE and SIB. As such, the report covers not only retail price data-collection for commonly consumed agri-food commodities, but also any market information along the entire agri-food value chain relevant to consumption, exports and industry. This information includes agri-input prices, post-harvest and processing costs, harvest yields and stocks on hand; input costs such as packaging, storage, and transport; and wholesale costs and markups before the commodity arrives to the consumer for consumption.

Ultimately, gold-standard market monitoring systems should perform the following functions:

- Allow governments to compute and forecast final-demand intermediate demand[3] (FD-ID) price-indices across any all economically vital value chains. This subsumes both consumer-price (CPI) and producer-price indices (PPI).
- Provide timely wholesale and retail market prices for agri-food commodities with respect to both source and varietal that can be disseminated globally via existing systems, for example those created by FAO, the World Bank and private-sector market-data providers such as Tridge.com.
- Combine supply, demand, and price data together to derive insights and produce actionable policy recommendations that balance price-stability with availability and encourage sustainable economic growth.

[3] FD-ID price indices aggregate prices of goods and services in an integrated manner; divided into final demand and various stages of intermediate demand, producing the Final Demand Index (FD index) and the Intermediate Demand Indexes (ID indices). Using the FD-ID price indices makes it possible to price transmission across the entire value chain for goods and services while avoiding the multiple counting of inputs at various stages of the chain (Bank of Japan, 2022).

While the report provides a strong entry point to advance on analysis of these issues, there were limitations. These include the limited availability of key informants from the various units within the government that operate price-monitoring systems. This report also focuses mainly on information attained through key-information interviews with the Policy & Public-Private Sector Interface Unit (PPSIU) of the Ministry of Agriculture, Food-Security, & Enterprise (MAFSE) and the Statistical Institute of Belize (SIB). The authors of this report were not able to interview representatives from four other units which are also collecting price information in some fashion or form:

- Belize Customs and Excise Department (BCED) electronically records volumes and prices for all registered imports and exports.
- Belize Bureau of Standards (BBS) collects prices to enforce price-controls and markups on specific regulated commodities.
- Belize Marketing and Development Corporation (BMDC) is the single largest food importer in the country with a mandate to providing marketing services for Belize's small agri-businesses. As a government-sponsored-enterprise under MAFSE, BMDC must record prices and volumes of agri-commodities bought and sold.
- The Cooperatives Unit under MAFSE is responsible for auditing cooperatives, therefore having access to price and volumes of commodities produced, stored, processed, and sold by these cooperatives.

As a result, the inclusion of related any information is based on second-hand knowledge of how these units' collect and store data and how it can be accessed.

1.3 REPORT STRUCTURE

The report is structured to provide a clear end-to-end understanding from what are market monitoring systems, to the activities of the relevant units within the government, and finally the identified gaps, challenges, and recommendations. There are four proceeding sections:

1. **Introduction –** This section introduces basic aspects around market monitoring systems from what they are, how the government utilizes the information, and finally what relevant information products are subsequently produced from indices to forecasts, and how they are disseminated.
2. **Current Market Monitoring Systems in Belize –** The various market monitoring systems in place within the government across its ministries, are mapped out in detail within this section. Specifically, this section dives deep into the data-collection and information management tools built by two of the primary ministries responsible for market data collection.
3. **Gaps in Current Market Monitoring Systems –** Given the mapping of the various systems in the previous section, this section identifies gaps and challenges with the current status-quo, why they are detrimental, and what may be the root cause behind these gaps.
4. **Recommendations –** Finally, this report provides in rank-order, ease-of-implementation and recommendations that can be implemented by the government to not only improve their

market monitoring systems, but also create synergies between ministries, achieve efficiencies, and move towards a best-in-class system.

The prose of the report makes use of lists and enumerated lists to purposely allow the audience to quickly find the content most relevant to their interest and to convey technical information in a clear, concise, logical manner, devoid of narrative or other forms of subjectivity.

2. Introduction

Prices are the coordinating force in a market economy. They communicate more than just profit and revenue and act as signals coordinating a vast web on economic activity, spanning global supply chains and international markets. Therefore, market monitoring systems play a key role in tracking and stabilization of markets, often with significant government resources directed towards it. The below section introduces the preliminaries of marketing monitoring systems from what they are, how they work, what data products they produce, and finally why they are important, especially to the government of Belize. The purpose is to ensure the reader has a foundational understanding of market monitoring systems before delving into the specific systems in Belize.

2.1 IMPORTANCE OF MARKET MONITORING SYSTEMS

Prices across value chains serve as economic x-rays, revealing the organs of production and disclosing ailments in the hands of a skilled practitioner. Without adequate public knowledge of these prices, markets themselves can fail to function, prey to price transparency and imperfect information. While this report focuses on agri-food commodities, market monitoring systems are vital across almost all sectors of the economy. The lack of high quality and regularly updated market information risks resulting in organizations and governments engaging in suboptimal actions if they do not have a holistic overview of this complex and changing reality.

With respect to the agri-food sector, market information enables transparency and fair returns for the actors in the value chain, including consumers. It provides early-warning signals of food insecurity, informs tariffs and quotas for agri-food imports & exports, and gives the impetus for responses to market disruptions and price shocks, such as the provision subsidies to those who need it. The *Agricultural Market Information System* guide points to the following benefits these systems provide (Inter-American Institute for Cooperation on Agriculture, 2016):

- **Reduces production risk** – encourages a healthy degree of supply while avoiding over production and enabling producers to forecast input costs;
- **Reduces market risk & sales cost** – greater transparency reduces margins for middlemen, while higher-resolution supply/demand forecasts reduce volatility due to supply-chain pathologies such as the bull-whip effect;
- **Identifies business opportunities** – encourages the entry of new entrepreneurs and exporters including in smaller, less developed geographies and sectors;
- **Optimizes productive investment** – allows both government and private sector to prioritize investment in capital equipment and infrastructure; creditors and investors receive the needed assurance that the business case exists to front the capital;
- **Encourages the development of secondary capital markets** – such markets allow investors to buy and sell existing debt, equity, and other instruments such as options and futures essential to agri-food commodities. This not only increases the capital base, but also

de-risks investment, reduces supply and price volatility, and permit producers to take advantage of economies of scale.

2.2 DEFINING AGRI-FOOD MARKET MONITORING SYSTEMS

The purpose of agri-food market monitoring systems is to collect timely, reliable, and accurate market information across that can be used by the different actors in the agri-food sector and decision-making processes, including government bodies, farmers, wholesalers, vendors, and consumers. The *Market Information Organization System of the Americas*' (MIOA) *Price Collection & Information Dissemination Manual* (Mesoamerican Fruitculture Project, 2015) provides the following elements to characterize a well-functioning agri-food market monitoring system:

- **Reliability and impartiality** – The information provided should accurately and objectively reflect market conditions.
- **Timeliness** – Information should be available to users in the shortest possible time after collection.
- **Relevance** – Provided information should be meaningful to the producer and the buyer based on the importance of product and marketing strategy.
- **Accessible** – There should no special privileges derived from its use with information available to all stakeholders.

Given the wide scope described above, it is perhaps easier to provide an overview of these systems step-by-step over the kinds of information it collects; where, how and from who to collect it; and finally, what informational products are produced as a result.

2.3 INFORMATION COLLECTED

With respect to agri-food commodities, information is not only limited to prices per quantity unit of measure but also includes information of supply, quality, varietal, origin, market conditions, constraints on trade and price of input factors (Mesoamerican Fruitculture Project, 2015) (World Food Programme - VAM, 2010).

- **Supply –** This is the best way to estimate consumer demand for commodities; the livelihood of traders depends on their ability to forecast demand correctly. This quantity can include stocks on-hand and stocks in-order.
- **Quality –** Often the first lever traders utilize to keep sale prices stable in the face of rising input costs is to reduce quality (first lever of elasticity). Quality includes not only innate characteristics of the product (taste, ripeness, firmness, color, lack of defects), but also its post-harvest handling characteristics, or *condition.*
- **Varietal/Cultivar –** Even a straight-forward agri-food commodity such as black-pepper can have many different varietals (six in the case of black pepper – Malabar, Tellicherry, Cochin, Sarawak, Lampong, Belem) each with different desirability and market-value (Tellicherry is

the most desirable per black-pepper). Hence why this is needed for any accurate estimate of price/supply/demand dynamics for an agri-food commodity.

- **Origin –** Where was the item produced? Is it domestic or imported? This information can give valuable insights into how the market may be adapting to over/under supply of certain commodities.
- **Market Conditions –** This is the trend and tone of stocks and supplies in the market, demand, and amount of business being done. This can be further broken down as follows:

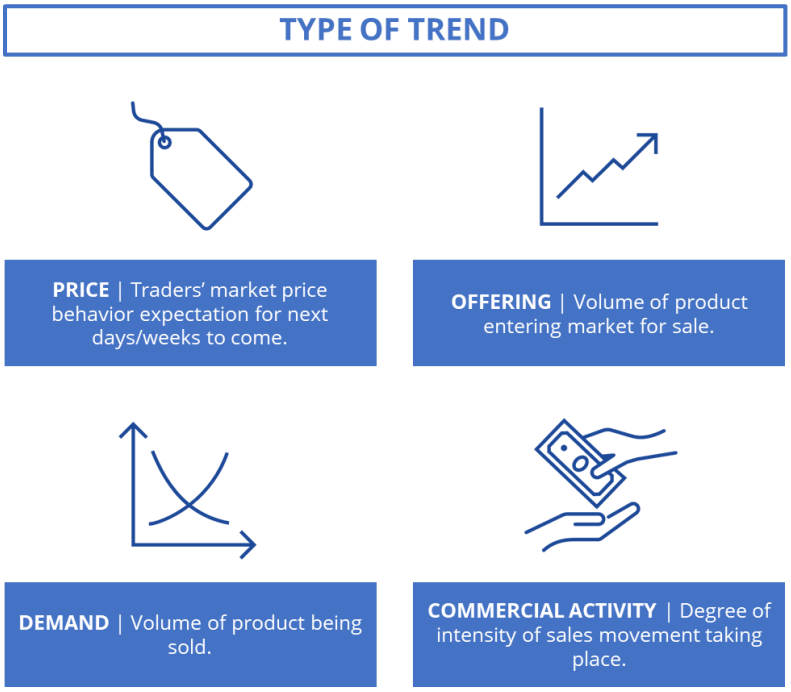


FIGURE 1. TREND AND TONE OF MARKET CONDITIONS (SOURCE: AUTHOR)

- **Constraints on trade –** These may include constraints imposed on business due to long-lead times on procurement; high costs of storage, transport, or packaging; limited warehousing capacity; and/or unavailability of credit.
- **Prices of Input factors –** For agriculturalists this includes raw material such as seeds, fertilizer, herbicides/pesticides, and land rents. For wholesalers and other middlemen this may include costs of packaging, storage, transport, and processing. For retailers, rents and labour costs may be big factors.

Finally, often times the quantity used to denote the price may be a non-standard metric such as a *bagful* or *bundle.* Factors converting such prices into standardized, universally usable units of measure is another key piece of information captured by the market monitoring system. It may not always be practical or necessary to collect all the above information, but this does encompass the base of data that denotes *market information.*

2.4 COLLECTION METHODOLOGY

The collected information must also be *representative*. Parsing this into its constituent components, the system must collect data in a manner that is (World Food Programme - VAM, 2017):

- **Timely –** Information should be provided to stakeholders at the frequency needed for their decisioning actions, or the frequency with which prices are sensitive to external conditions. Additional factors may drive the need for additional frequency, for example when a natural disaster occurs.
- **Spatially & demographically representative –** The catchment areas of the selected markets should cover 25-50 percent of the population with balanced representation amongst demographic groups (especially urban vs rural). Markets that serve as hubs for regional distribution or particular value chains are of particular importance.
- **Encompasses the entire value chain –** Agri-food commodities are produced, bought, and sold at multiple levels with usually a minimum of three levels—producers, wholesalers, and retailers. Additional tiers can include import and processing depending on the nature of the commodity.
- **Covers representative volume –** Ideally the data collected should be representative of 50 percent of the volume in the market, meaning the data collected as close to possible post market volume spikes within the collection interval and from a representative cross-section of traders covering both large and small amounts of volume.
- **Includes a representative cross-section of items & varietals –** Commodities covered should comprise not only a representative household food basket, but also include major import and export commodities and seasonal items. It is also important to consider different varietals that are important as a socioeconomic measure or capture substitution effects (e.g., whole vs broken rice).

Data is generally collected using one of two modalities by well-trained enumerators. The market monitoring system relies on statistical sample surveys taken from shops and other retailers across a representative cross section of agri-food commodities, or it utilizes key informants when statistically representative surveys are not possible. Data is instead collected from a selected traders who have been trained and incentivised to provide quality information.

2.5 INFORMATION PRODUCTS AND DISSEMINATION

Many different information products can be constructed from the data as there are a myriad of uses stakeholders have, from street-vendors knowing which market to sell goods at all the way to central-bankers forecasting inflation and setting monetary policy. The most important of these information products are detailed below:

- **Price indices & sub-indices –** This is a directly applicable output by describing the price-time-series of a commodity over time. This can be further subdivided by geography and different varieties. However, these indices are often far more than simple arithmetic

averages. Careful attention needs to be paid to observation-weights observations to ensure the price-index is representative spatio-temporally and across varieties of the underlying commodity that it represents. Furthermore, given inflation and the panel-structure of data, the arithmetic-mean itself is often a poor choice, requiring more advanced statistical techniques for index construction.

- **Consumer Price Index (CPI) –** The CPI is the price of a representative basket of goods purchased by a household and is in itself a weighted sum of the above price-indices. Just like with prices, the CPI can be broken down geographically and careful attention needs to be paid to weights that may vary spatio-temporally. The annual percentage change in CPI is used as a measure of inflation. More importantly, the CPI represents the real purchasing power of households given fixed wages and is used to adjust pensions, wages, interest rates and a host of other economic levers.
- **Producer Price Index (PPI) –** The PPI measures average changes in prices received by domestic producers for their output, therefore it is composed of prices at the wholesale or farm-gate level and agri-commodities either grown or processed indigenously. Like all indices it can be broken down sub-nationally and by industry. It is viewed as a good pre-indicator of inflationary pressures.
- **Farm Input Price Index (FIPI) –** The FIPI, as its name suggests, measures changes in input prices for agriculturalists (EuroStat, 2020). The FIPI is in general a class of FD-ID indices that track prices at each stage of the value chain. Conveniently, they can be constructed using CPI and PPI sub-indices. FD-ID indices for various agri-food value chains are the gold-standard for well-functioning market-price information systems.
- **Minimum Expenditure Basket (MEB) –** This is equivalent to the CPI but with respect to a pared-down basket of goods representing the minimum the average household needs for food, shelter, and other essentials. The MEB is frequently used to determine poverty levels and direct social-protection programs.
- **Labour Terms of Trade –** Normalizing the daily-wage (unskilled or low-skilled) wage-labour prices by the MEB gives the terms-of-trade for labour (i.e., ratio of daily wages earned to minimum expenditure needed). As wages usually change much more slowly than prices, this is a powerful measure of household budgeting pressures consumers face given changes in prices.
- **Price Spikes & Early Warning –** Increased price volatility, in particular unexpected spikes and/or troughs, can be a powerful early warning signal indicating supply chain issues, crop failure, or other economic pressures. WFP's *Alert for Price Spikes* (ALPS) is a functional example of such a product (World Food Programme - VAM, 2014).
- **Elasticity –** Elasticities measure how quantities demanded will adjust in response to a price or income change - or, inversely, predict price changes due to changes in supply. This enables policymakers to gain a sense of how consumers and businesses may react to price, supply, and income fluctuations.
- **Market Integration –** This measures the degree to which markets balance supply and demand by bringing commodities from areas of surplus to those with deficit. Such

integration is desirable as it lowers volatility and creates market resilience. Poorly integrated (segmented) markets can indicate high transaction costs, poor infrastructure, or monopolistic (and often illegal) rent seeking by businesses.

Last but not least, it is important to note price and demand forecasts are of invaluable use to businesses and producers. Small surpluses in supply can cause commodity prices to crash, while supply deficits can cause inputs to become prohibitively expensive (especially if the commodity is inelastic). Production, including farming, has long lead times and resources are wasted if the product cannot be sold. Such forecasts may also encourage businesses to pre-book orders, not only reducing price volatility but generating revenue stability that is needed to undertake long-term capital expenditure.

All these information products must be disseminated and accessible for users to make timely use of them. The importance of this cannot be understated, in the United States the Agriculture and Food Act of 1981 mandated transmission/disseminations costs to be covered for anyone that wanted access to this information. While publishing on websites and printing reports are standard practice, in the current technological age the application programming interface (API) reigns as the primary mode for data sharing. This is a *software* interface (as opposed to a *user* interface) by which any authorized web application can query and retrieve the information using standard web-application programming frameworks. Via APIs, pre-existing open-source tools allow user products to be built, from dashboards to rich visualisations, to easy global dissemination through platforms such as FAOStat and the World Bank.

2.6 RELEVANCE FOR THE GOVERNMENT OF BELIZE

Belize's agricultural sector has historically dominated its economy. As of 2020, it contributed approximately BZ$590 million annually to economic output, representing 80 percent of domestic exports and directly employing 17.9 percent of the population (Belize Ministry of Agriculture, 2015). Moreover, it is a major foreign exchange earner, maintains a vibrant rural population and ensures food and nutrition security for the country. In addition, Belize is a major food importer, totalling US$135 million in 2020 or 21 percent of all food consumed (World Bank - WITS, 2022). All of these agri-food commodities move through multiple markets from the farm-gate or import level, through aggregators and distributors at the wholesale level, and finally to shops and vendors at the retail-level. The dynamics of these markets roughly determines 21 percent of the CPI, i.e. the household budget of the average Belizean household (International Center for Tropical Agriculture, 2018).

As Belize is a relatively small country with a high degree of administrative centralization, the government has at least six immediate domains of responsibility where this information is vital:

FIGURE 2. MARKET MONITORING INFORMATION RELEVANCE FOR BELIZE (SOURCE: AUTHOR)

2.6.1 Price-control regulation

Since 1984 under the Supplies Control Act, price controls are administered on two general categories of goods in Belize. Over fifty imported goods along with a long list of imported medical supplies are regulated by maximum legal markups. Twenty indigenously produced items are also controlled, in particular five basic foodstuffs – 16 oz bread loaf, sugar, red beans, flour, and grade C rice – along with butane gas and fuel have strict prices set by district. Prices are set by the Price Control Committee composed of various representatives of ministries and trade unions. However, it is the Supply Control Unit of the BBS that is the primary monitoring and enforcement body (Loehr & Associates, Inc, 1994).

2.6.2 Quotas and tariffs on imports

As 21 percent of the food consumed in the country is imported and much production is seasonal, the MAFSE sets quotas on agri-food imports into the country. The Ministry of Finance sets the tariff although these have been normalized under The Common External Tariff of the Caribbean Community established by decision of the Council for Trade and Economic Development (COTED). Setting these quotas is a delicate challenge wherein the ministry must ensure price stability for consumers and favourable terms for farmers with adequate supply given multi-month lead times. This is one of the primary reasons why MAFSE implements an independent market monitoring system.

2.6.3 Economic Indices, Fiscal and Monetary Policy

SIB has a wide mandate ranging from the census to the computation of the CPI. Statistics and indicators for labour force wages & participation, merchandise trade, tourism & manufacturing activity, gross domestic product, and poverty rates are all under the purview of SIB. This information in-turn is crucial for the Central Bank of Belize to avail of its monetary tools at its disposal including management of foreign reserves, dictating bank reserve ratios, and regulation of various interest rates. In particular the CPI and terms-of-trade are absolutely vital. Likewise, the Ministry of Finance sets fiscal policy and issues interest bearing treasury notes and bonds sensitive to the inflation rate as measured by CPI and the economy's productivity growth. As Belize is a small country, even small changes in interest rates, exchange rates, or government borrowing can have major consequences on public finances. Fiscal stimulus can also very quickly lead to inflation if the productive capacity is not present to convert to sustained economic growth.

2.6.4 Farmer and agriculture welfare

While Belize does not directly implement blanket farmer subsidies and minimum price supports as is common amongst highly developed countries for certain commodities, there are a number of supply -side market interventions instituted by MAFSE to promote farmer welfare and national food-security. First, farmers are provided subsidies from time-to-time especially with respect to fuel, fertilizer, and other agricultural inputs. This is often consequent to shocks as there is little to no crop insurance available; for example, in 2019 assistance was provided to sugar-cane farmers following a drought (Press Office - Government of Belize, 2019). Second, when direct subsidies are not provided MAFSE seeks to provide preferential interest loans for agri-inputs and machinery. While the research did not identify the scale of the programme, it has commenced through several farmer cooperatives in the country. Finally, MAFSE does have the ability to directly intervene in the market through the Belize Marketing and Development Board (BMDC), a government-sponsored enterprise that acts as the single-largest wholesaler of agri-food commodities in the country. Prior to lifting import restrictions, towards the end of a crop season, it is often the BMDC that purchases the remaining supply of the crop from farmers.

2.6.5 Social protection and food-security

To determine the poverty rate, district level incomes are compared against minimum expenditure (MEB) basket tabulations, the average cost of the minimum amount needed by a household to provision food, shelter and essentials. This informs the calculation of cash transfers, vouchers, and/or other social protection and similar programmes undertaken by the government and partners such as UN agencies. Furthermore, low income urban populations with greater dependence on markets often face increased levels of food insecurity. Results from the latest round of the Regional Food Security and Livelihoods survey implemented in the Caribbean in August 2022, which was implemented by WFP on behalf of CARICOM in Belize highlighted that lower income households are disproportionality affected by the cost of living crisis, showing poor key metrics relating to their access to markets, food security and livelihoods. Indigenous communities may also face unique challenges due to their cultural, farming practices and locality. Generally, understanding the evolving

costs of goods is important for tailoring support to vulnerable groups and those living in poverty, as their ability to meet basic needs is impacted by price rises and supply chain disruptions.

2.6.6 Commercial and industrial planning

Trade licensing is required for most businesses in Belize operating beyond the micro/small scale (vendors, small-holder farmers, entertainers are exempt) granted by the Ministry of Labour, Local Government, Rural Transformation and Community Development under the Trade License Act. Licensing and permitting necessarily requires the ministry to understand industrial organization, supply chain dynamics, and market structure for various sectors of the economy. Moreover, economic development funds, investment, and industrial subsidies are very meticulously directed by the ministry under a new mandate to encourage public-private partnership under the Public Private Partnership Concession Laws of 2021 (World Bank - PPPLRC, 2021). These laws are designed to not only spur additional infrastructure development, but also additional value chain capture by Belizean corporations through greater value added services in the agricultural and chemical sectors.

3. Market Monitoring Systems in Belize

There are four government institutions in Belize responsible for collecting agri-food commodity market information. Two are auxiliary, BBS and BCED, and MAFSE has multiple units within it with relevant price related data. However, the two workhorse market monitoring systems for the entire country are the Belize Agriculture Information Management System (BAIMS), part of MAFSE, and the CPI unit of SIB. These information systems will be examined in detail.

3.1 BELIZE CUSTOMS AND EXCISE DEPARTMENT (BCED)

All imports and exports into and out of Belize (except for unsanctioned trade at unregulated borders) must go through BCED. Tariffs account for 53 percent of government-revenue, making BCED the single biggest income source for the government (US International Trade Administration, 2022). Prior to import, businesses must have filled an electronic warrant that declares the items imported, quantity, weight, value, and associated tariffs and taxes paid.

Commodities are categorized according to the Harmonized Commodity Description and Coding System (HS) system developed by the World Customs Organization (WCO)**.** Upon import, the importers must also present the counter-signed invoice from the seller which should have the same HS code and value as declared on the warrant. However, this process is yet to be digitized. Invoices are reconciled with warrants manually (if the shipment is large) or by random check. BCED uses an UNCTAD (United Nations Conference on Trade & Development) – developed software tool known as ASYCUDA (Automated System for Customs Data) to log and maintain all this data. This software is highly successful and used in over 80 countries (ASCYUDA, 2022).

BCED is not responsible for trade-statistics, but every month they do work with SIB to tally and report aggregated quantities of tonnage/volume and price for certain classes of goods. However, these reports remain PDF documents and aggregates remain macro-level, with no ability to match price and volume to specific agri-food commodities via the HS code. If needed for analysis, the raw data can be requested from BCED.

Information on the quality of agri-food imports that information is situated with the Belize Agriculture Health Authority. They are responsible for checking the quality and safety of all agri-food inputs including pre-clearance at the country-of-origin through inspection by a trusted third party or certification by a trusted body (for example USDA approved items are pre-cleared). In general, most agri-food inputs are pre-cleared, avoiding any strenuous inspection.

3.2 BELIZE BUREAU OF STANDARDS (BBS)

Belize Bureau of Standards is responsible for monitoring and enforcing price controls. This includes maximum allowable markup percentages for certain commodities and retail-level price controls for which there are only five food commodities (Breaking Belize News, 2022):

- Brown and white crystalline sugar;
- Grade C rice;
- Sliced and unsliced plain white bread (16 oz loaf);
- Red beans; and
- Bebe Agua (Baker's) and La Gitana (All Purpose) flour.

In addition, petroleum, diesel, and butane gas are the other commonly used price regulated commodities monitored by BBS.

These price controls are enforced via price-control officers employed by the Supply Control Unit (SCU) of the BBS. Plain clothed officers randomly visit retailers and wholesalers and then check prices and invoices on the aforementioned commodities. The research did not ascertain how frequently these random market assessments are performed or how extensive they are. With inflation a pressing concern owing to the global price crisis, the BBS has increased its enforcement of price controls. Violations usually result in fines and possible seizure of goods, but in the extreme case suspension of business and prison is possible. However, as the activities of the SCU are considered a legal matter, it is not clear what if any price information is systematically retained by these officers, if any digital monitoring system is present, or if and how the data could be made public.

3.3 MINISTRY OF AGRICULTURE, FOOD-SECURITY, AND ENTERPRISE (MAFSE)

As agriculture is a dominant sector in Belize, MAFSE is a highly trained organization with an extensive network of field offices dotting every district in the country. This enables them to run one of the most comprehensive agricultural monitoring operations in the Caribbean using a system coined Belize Agriculture Information Management System (BAIMS). BAIMS not only covers retail prices for commodities at all the major food markets in the country but is built ground-up as an information warehouse for every farm and farmer in the country. It can accommodate information on inputs, supply, condition/production, and farmgate by commodity and varietal/cultivar at the farm-level. BAIMS is covered in greater detail later in this section.

The Policy and Public-Private Sector Interface Unit (PPSIU) is the department within MAFSE responsible for BAIMS. There are also two additional units within MAFSE—the Belize Marketing and Development Board (BMDC) as mentioned earlier, and the *Cooperative Department*—that are also extensively collecting agri-food market-related information for their own internal operations. While their data is not collected for the purpose of market monitoring, it is highly relevant. However, this

research was not able to dig deeper into what market monitoring systems are present and publicly available within these two departments.

3.4 BELIZE AGRICULTURAL INFORMATION MANAGEMENT SYSTEM (BAIMS)

BAIMS was initially started as a project for Belize's 2018 Agricultural Census as part of their 2025 Strategic Plan for Agriculture and Rural Statistics. This survey covered every farm and farmer in the country, digitally registering 16,000 farms and 14,500 farmers and providing farmer registration cards. Enumerators and survey statisticians needed a fast, flexible, electronic tool with which to collect, store, and manage an incredibly diverse amount of data from pictures of farms and farmers to farm-gate prices on commodities. The requirements for this tool were significant, with PPSIU needing web, mobile, and tablet capabilities, offline and online data-collection ability, ad-hoc new question flexibility, and user-permissioning across enumerators, analysts, and administrators. The Central Information Technology Office (CITO) built the tool, taking lessons from previously implemented agricultural information systems.

FIGURE 3. BAIMS INTRO SCREEN

3.4.1 Information collected

In general, BAIMS is built around a customer relationship management (CRM) framework. Its primary purpose of is not to collect market prices but farmer and farm-level information and administering interactions between MAFSE and the farmers, such as disbursement of subsidies or technical assistance. Market prices are an ancillary product added later to the BAIMS system. Nonetheless much of the information collected by BAIMS is highly relevant either directly—in terms of capturing farm-gate prices, production quantity, and inputs—or indirectly, for example, farm geo-coordinates that can be used to forecast supply. Below is by no means a comprehensive list of information collected by BAIMS, but relevant to agri-food markets:

- **Famer ID and socio-demographics (14,500 farmers) –** Each farmer in the census is uniquely identified with relevant sociodemographic info (education, age, income, etc.). Particularly relevant is the tenancy type (own, rent, share-crop) and duration over their land. Farmer skill, especially with respect to knowledge and experience with their specific plot, has a tremendous impact on productivity.
- **Farm acreage and geocoordinates (16,000 farms) –** Each farm can be connected to its respective satellite imagery using the acreage and geocoordinate values, allowing MAFSE to conduct surveillance via satellite. This enables MAFSE to provide early warning of pests and other diseases, technical advice on water-management and climate-change resilience, and accurately estimate crop progress and yield.
- **Acreage planted and/or livestock headcount (by varietal and season) –** With this information MAFSE can theoretically estimate the unit economics of the farm, from expected yield and revenue to input-prices and profit.
- **Dates for pre-planting, planting, and harvest (by varietal and season) –** This information not only helps track expected future supply of agri-commodities, but also demand for agri-inputs as farmers fertilize, irrigate, and fumigate their crops at particular times during the cropping cycle.
- **Damage and losses (pre-harvest and post-harvest by season) –** This includes the acreage/heads of permanently lost crop/livestock, value-loss from repairable damage, and what caused the preceding damage/loss (e.g. pest, disease, natural disaster, insufficient inputs).
- **Quantities sold and stocks available (by varietal and season) –** Not all product is immediately sold post-harvest. Farmer stock is extremely relevant information to understand supplies available and market constraints.
- **Subsidies received –** Farmers often receive subsidies for various items whether it be agri-inputs, fuel, or direct-supports following natural disasters. Subsidies by their very nature can have distortionary effects on markets, hence its importance.
- **Farm gate prices & quantities (by season for 190 varietal-commodity pairs) –** Prices and amount for commodities directly sold by farmers as income are headline items for any agri-food market-information system.

- **Market prices (weekly for 57 commodities) –** Likewise these prices are the cornerstone of any agri-food market-information system. However, BAIMS only collects market-prices for 57 of the most commonly consumed commodities at seven open-air food markets across the country.

3.4.2 Methodology & Technology

BAIMS heavily relies on field-visits by trained agriculture extension officers to gather information. While this method is costly, it does generally yield the highest quality data, as the officer can visually verify farmers' responses, offer follow-up questions, and provide advice, genuinely building a strong rapport with farmers. Sometimes the farmers visit the extension offices themselves, perhaps when needing assistance with pests or disease, and follow-up can be performed remotely, as the system also contains farmer contact information.

With respect to market price monitoring, the data is also collected via field-officers largely using paper and pencil as tablets were considered too cumbersome. Open-air markets are held a minimum of once a week in each of the two cities and seven towns of Belize. Two towns are currently excluded from BAIMS's market-price collection—San Pedro, a major island tourist destination, and Benque Viejo del Carmen, the Westernmost town in Belize with most food coming from Guatemala. Due to these unique characteristics, MAFSE does not consider them mission critical. The 57 food commodities are universal across all markets, and BAIMS has pre-defined the unit by which to collect the price. The methodology is as follows:

1. **Timing & Frequency –** Every week markets in these locations are held at least once a week if not every day. agriculture extension officers visit at 7-8 AM in the morning on the busiest day of the market. This is typically Friday or Saturday.
2. **Key Informant Selection –** Prior to data collection the officer already approaches vendors to cultivate relationships. He or she explains what information is being collected and why and ensures that they will not be identified in anyway. He or she explains which commodities they are collecting data for and by what unit. In so far as possible data is collected as a panel, approaching the same vendors every month. No monetary incentive is offered.
3. **Samples & Collection Modality –** Depending on the market the officer approaches three to five vendors per commodity, ten to fifteen vendors total across commodities. Data-collection occurs rather quickly, finished in under 45 minutes. The agricultural officer verbally asks the vendor for the prices and he or she rattles them off. With the exception of a select few commodities where imported varietals are considered superior such as rice, no information is collected on varietal of products or weight of products sold by unit.
4. **Data Processing & Calculation –** The officer tabulates prices across commodities once back at the office. After cleaning the data, the preferred method is to report the modal price across samples if a majority of the samples (two out of three or three out of five) are in agreement. Otherwise, the arithmetic mean is reported. The tabulated values are uploaded

into BAIMS after being manually computed using spreadsheet software such as Microsoft Excel.

3.4.3 Outputs & Dissemination

BAIMS disseminates outputs using several modalities:

- PDF documents with prices across markets are posted on Facebook. Additional short videos of the prices are posted on Facebook and forwardable via WhatsApp.
- The above PDFs are also posted on the BAPIS (Belize Agricultural Price Information System) website.
- The prices are also shared with radio and newspaper outlets who will usually mention if certain commodities have experienced extreme movement.

There is little indication that the BAIMS data is disseminated in a manner consumable by international agri-commodity price outlets such as World Bank Pink Sheets, RaboBank Agri-Commodities, or Tridge.com. Neither is it clear that it is consumed by regional agricultural price monitoring systems, such as the USDA or MIOA, or international systems such the WFP's Price Explorer or Food and Agriculture Organization's FAOStat.

3.4.4 Belize Marketing & Development Corporation (BMDC)

As mentioned before, BMDC is the largest single food importer and wholesaler in the country. It is also a government-sponsored enterprise and hence operated as a private company with its own profit/loss ledger, balance sheet, and mandate to turn a (small) profit. Presuming modernized accounting and control systems are present, BMDC should have extremely granular information on the following:

- Type (including varietal), volume, origin, and price of agri-food commodities purchased
- Cost of other inputs such as transport, storage, and packaging
- Price, destination, and volume of sold commodities

Typically, as most agri-food wholesale markets have a leader-follower dynamic, large traders such as BMDC set the price, trend, and tone for the whole market.

One can surmise that their information is electronically stored within the accounting and controls software. As BCED (excise & controls) also forces importers to use HS codes (World Trade Organization Harmonized Codes) for agri-food commodities, it should then be possible to easily map BCED's commodities to those tracked in BAIMs. However, this is only theoretical, as it does not seem any of the data is accessible to authorized 3rd parties via API or other electronic means.

3.4.5 Cooperatives Department

The *Cooperatives Department* of MAFSE is responsible for encouraging the creation and profitably of agricultural cooperatives throughout the country while also executing regulatory responsibilities such as cooperative registration, maintenance and audit of records and dispute resolution. Given their scope of responsibilities with cooperatives especially with respect to record maintenance and

audit, it stands to reason the Cooperative Department would either have or be able to easily attain the following information:

- **Quantity & wholesale price of agri-inputs (by farm and commodity) –** Typically cooperatives purchase agri-inputs wholesale and sell to farmers at or near cost with generous credit-terms, allowing the farmer to re-pay after their crop is sold.
- **Farm-gate volume & price (by farm and commodity) –** While farmers may or may not be contractually obligated to sell their output to the cooperative (and even so contract-compliance is often poor) the cooperative generally is usually to whom the majority of the farmer's output is sold.
- **Harvesting, processing, & storage costs (by commodity) –** Generally harvesting equipment and storage and processing facilities is owned by the cooperative. Labour needed for harvesting is also often arranged by the cooperative. Either the farmer rents these facilities, or the cooperative incurs these costs on their own income statement.
- **Wholesale price of commodities sold –** Commodities purchased from farmers are sold by the cooperative to wholesalers or sometimes directly to retailers or intermediary processors of food commodities.

As mentioned earlier, the Cooperatives Department does not seem to have their information stored and indexed in a manner that can be digitally accessed by authorized parties.

3.5 STATISTICAL INSTITUTE OF BELIZE (SIB)

SIB has an expansive footprint over all demographic and economic data collection and statistical analysis. Production of the Consumer Price Index (CPI) is amongst the tasks for which SIB has a dedicated team. Before diving further, it would be helpful to understand what CPI and its relevance to market price information is.

BOX 1: WHAT IS CPI? HOW IS IT COMPUTED?

The CPI is a commonly used economic measure of the prices faced by consumer in the market, composed entirely of data on prices collected from consumer goods and services outlets. Hence it is an incredibly rich source of market information. CPI also serves as the primary measure for inflation and is vital for many economic and monetary functions. It is constructed in the following manner:

1. **A representative household basket of goods along with associated quantities is tabulated for the population of interest.** This basket should include all the consumption required for a representative household from shelter, food, transport, clothing, medicine, education, and more for a specified period of time (usually one month). This basket is typically hundreds if not thousands of items with incredible variation across different socio-demographic groups.

2. **A representative set of prices is computed for each item in the above basket.** When one considers the sheer number of varietals and brands that even a single item such as "coffee" may have, computing a single representative price can be quite a challenge. There is usually a need to first compute weights across the many products available in the market that map to a particular item in the CPI. Moreover, there is also a need to ensure the prices themselves are collected in a representative manner, covering a representative range of outlets from street-vendors to luxury shopping malls. Therefore, if the price sampling itself is not representative, then another set of weights is required. The result is a price index on the item level (e.g., Coffee Price Index).

3. **The CPI is calculated for the representative basket of goods normalized against a particular time-period.** The calculation of the CPI is fairly straightforward once the individual price indices are computed in step 2. Often times multiple CPIs are calculated by geography and/or socio-demographic groups. Moreover, the CPI is usually referenced to a particular time period (e.g., the year 2000) and normalized, so the index represents the percent increase/decrease in consumer-prices since that year. The CPI can also be computed in *nominal* terms as just described, or in *real* terms where we remove labour-cost inflation. The latter statistic allows us to truly understand changes in purchasing power for the population.

3.5.1 Information Collected & Methodology

SIB restructured their methodology in 2020 (Statistical Institute of Belize, 2020) after nearly a decade, following the 2018-2019 Household Budget Survey, which covered a nationally representative sample of approximately 3,000 households across both urban and rural areas in all districts of the country for a period of 12 months. The size of the basket was increased from 260 to 409 items while increasing the geographic coverage and representativity of samples. The resulting methodology is summarized below:

- **Basket Construction –** SIB constructed their household expenditure basket from the 2018-2019 Household Budget Survey. Nine different expenditure baskets were constructed for each of the following regions of the country—Corozal, Orange Walk, Belize City, San Pedro, Belmopan, San Ignacio, Benque, Dangriga, and Punta Gorda.
- **Item Selection and Weights –** Across all nine regions there are 409 items in the national expenditure basket of which 142 are agri-food commodities. An *item* is a specific agri-food stock-keeping unit (SKU) defined by not only the commodity, but its specific varietal, brand, and quantity (e.g., 250 grams of Nestle Nescafe Gold freeze-dried granulated coffee*).* These 409 items can be mapped to 13 broad expenditure *divisions* as defined by the Classification of Individual Consumption According to Purpose 2018 (COICOP). Between *item* and *division* there are two levels of finer granulation, with *items* mapping to commodity *classes* to which expenditure basket weights are assigned. All items within a particular commodity class have the same weight.
- **Timing and Frequency –** Prices for non-food items are collected on a rolling-basis quarterly, with data-collection occurring at the middle of the month every month. 200 selected commodities, including food and fuel items are collected monthly. This allows SIB to maintain a separate monthly CPI of the most sensitive commodities and use an average across months for the quarterly CPI.
- **Sampling –** Prices for items are collected across a broad, representative panel of 2,706 retail outlets throughout the country, stratified by small, medium, and large outlets. However, open air markets/vendors are not included which comprise almost all the nine open-air food markets of the country. The prices are the final prices paid by the consumer, inclusive of all taxes and other surcharges. Promotional prices are not discounted in any way from the CPI construction and are fully reflected as is. A minimum of five data points must be collected for each item in each enumeration area (at level of a small town or village). Over 8,000 samples are collected every month.
- **Substitution of items in panel –** A frequent issue that arises during data-collection is the substitution of missing items from the item list when they are not available at a particular outlet or location. This can happen simply because the item is on back-order, or it has been discontinued. Enumerators are well-trained and best placed to select substitutes. However, it is implicitly assumed that *quality* creates the price-differences in the same period within the same commodity *class* of items. So, prices for substitutes are carefully adjusted to match

the original quality of the substituted item prior to index tabulation. If the item is missing for three consecutive months, then it is entirely replaced.

- **Imputation of missing prices –** As mentioned earlier, a minimum of five samples, per item, per enumeration area is required at a minimum. However, sometimes that is not achievable, and neither is an appropriate substitute available, in which case SIB is forced to impute. To do this SIB applies the change in the price from the last known period to the current period as computed from samples at the next higher level of geographic aggregation. For example, if a town has multiple enumeration areas and one enumeration area needs to impute the price for 250 grams of Nestle Nescafe Gold freeze-dried granulated coffee at a particular retail outlet (no substitutes available), SIB will apply the mean percentage change in price for that item across all the other samples of the town (across enumeration areas) to the previous known price of that particular item at that particular retail outlet.
- **Calculation & Index Construction –** SIB uses a Geometric-Laspeyres type construction to produce their CPI indices, a recommended best-practice because the relationship between prices is usually multiplicative in nature. This means that prices go up or down on a percentage basis rather than an absolute basis. For example, a shopkeeper may adjust all prices by 5 percent to account for inflation, but never add BZ$5 blanketly across prices. Intuitively, one can understand why this percentage basis innately makes sense. In a Geometric-Laspeyres index one takes the weighted geometric average of the ratio of the current price with the reference period price for the item. The reference period for prices is the month of October 2020 (reference for weights is 2018-2019). Each observation has its reference denominator, being the 2020 price of the item at the respective retail outlet. SIB first constructs indices at the regional level (for each of the nine different expenditure baskets) and then the regional indices are coalesced using population weights to create the national CPI.

3.5.2 Technology & Data Collection

SIB has built a state-of-the-art data collection tool through which it administers its entire CPI data collection operation. It is composed of two components, a tablet-based app that directs, guides, and collects data from enumerators, and a web-based admin console that allows supervisors to configure items and outlets, monitor progress, and approve and modify substitutions.

The tablet-app delivers end-to-end coverage over the tasks required of enumerators in a matter similar to commonly used platforms such as Uber. Enumerators are temporary workers hired and trained by SIB for the purpose of price-data collection. They typically have other income sources as well, but spend anywhere from 2-5 days per month on price-collection with SIB. As the enumerators are hired locally, this allows SIB to run an efficient data-collection enterprise throughout the country with minimized travel-time and parallel data-collection. Once data collection commences, the app performs the following functions:

1. Each enumerator receives a detailed map of his or her enumeration area and an optimized route of the outlets that he or she must visit.
2. Once at the outlet, the enumerator receives the full list of items in the order of a counter clockwise circumnavigation of the outlet.
3. By selecting an item in the list, the enumerator receives a detailed description, desired quantity, the previous period's price, and a picture if the functionality has been utilized.
4. If the exact item is present, the enumerator simply enters the price. If the price difference is more than 20 percent of the previous period's price or 20 percent of the average price in the enumeration area, then the enumerator must also write a detailed description as to why this is the case. Upon finalizing, the app automatically records the timestamp and GPS-coordinates of the enumerator's phone.
5. If the exact item is not present, the enumerator must enter a substitution through the app. The substitution and subsequent data entry must be approved by an administrator who is notified via an automated email. The administrator can review, approve, and reject all through the admin console.
6. it is important to note that the app has full-offline with re-sync functionality for use in remote-areas, emergency settings and times of inclement weather. While this might seem straight-forward, engineering such functionality can be quite difficult.

The admin console not only allows configuration of items, outlets, and enumeration areas and tasks, but also critical data-export functionality with extensive slicing and aggregation ability. The data is stored in such a manner such that raw source-of-truth, staging, and production versions are always readily available and undestroyable barring catastrophic data-loss. Full-data audit capabilities are present such that finalized, production data can be reconstructed from its original raw form. Together, the two apps create *a CPI platform* that is maintained in-house by the IT unit of SIB.

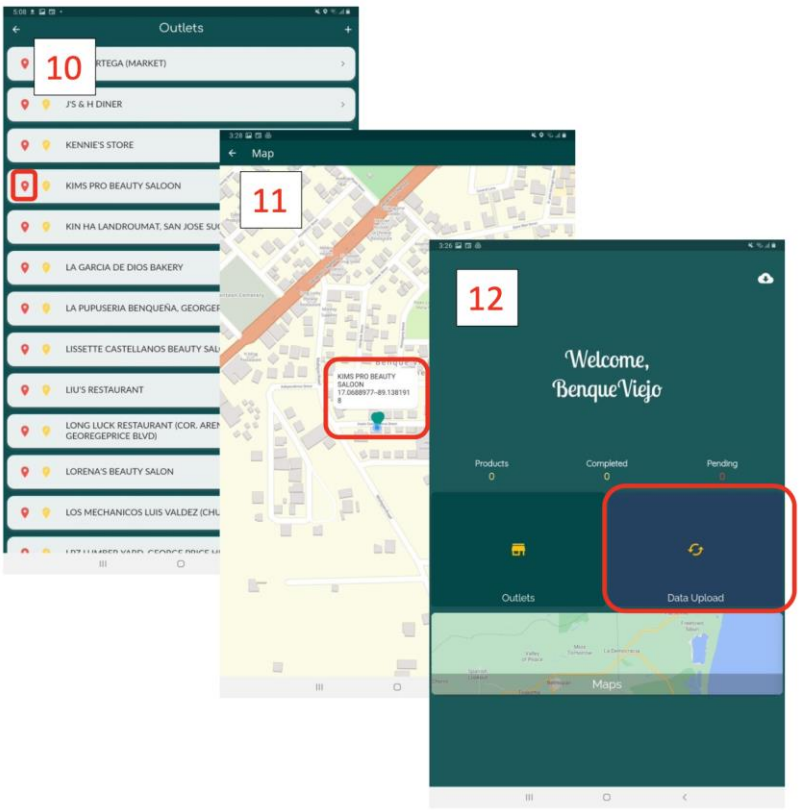
FIGURE 4. SIB'S CPI APP DATA COLLECTION TOOL

3.5.3 Information Products & Dissemination

SIB publishes several files compiled from the CPI data on their website monthly:

- A table of the national average price along with year-on-year percent change for 30 food commodities and five fuel commodities.
- A Microsoft Excel spreadsheet of the month-on-month national CPI both aggregated and broken down by the 13 broad household expenditure divisions as defined by COICOP.
- A Microsoft Excel spreadsheet of the monthly and quarterly inflation rates, also nationally aggregated and broken down by the aforementioned 13 COICOP expenditure divisions.
- A report in PDF format, discussing the data, highlighting the important changes, and delving into potential reasons for the observed changes. Within the report, the inflation rate is broken down by the nine different major population centers around which the expenditure basket is constructed.

At least on an annual basis, this data is consumed by World Bank, CEIC Data, St. Louis Federal Reserve Bank and other globally important institutions that disseminate price and economic data. However, the month-on-month data is not reflected in these data-platforms or other platforms



specifically related to agri-commodities, such as Tridge.com, WFP's Price Explorer or the Food and Agriculture Organization's FAOStat.

4. Gaps in Market Monitoring Systems

The previous sections reveal how there are several institutions collecting market information, often in sophisticated ways. However, these are largely operating in silos, with extremely valuable data inaccessible in any automatable way between various government systems. It is certainly within reach to have gold-standard agri-food market-information systems, producing monthly Final Demand-Intermediate Demand (FD-ID) price indices across multiple agri-food value chains. The primary impediments are not insurmountable information gulfs, technology, nor technical expertise, but simply perfunctory information gaps and coordination efforts. The challenge is largely digitizing and integrating information already being collected and/or generated by various units within the government.

4.1 INFORMATION GAPS

Both SIB and MAFSE along with other parties who regularly avail of their information, readily admit of the information gaps in their market monitoring systems. SIB not only lacks the required information to compute PPI, high on their priority list, but also their CPI data currently lacks prices from the country's nine major open-air markets that sell a sizable percentage of the food consumed by Belizeans in their home. Likewise, MAFSE only covers a fraction of the commodities covered by SIB. Broadly, the current information gaps fall under six major categories:

4.1.1 Geographic Coverage

As mentioned earlier, MAFSE is currently not collecting prices in San Pedro, a major island tourist destination, and Benque Viejo del Carmen, the Westernmost town in Belize, bordering Guatemala. Simultaneously, tourism directly and indirectly contributes approximately 40 percent to GDP (Chow, 2019), and the country shares respectively 272 and 266 km of land-borders with Mexico and Guatemala over which there is significant un-regulated/semi-regulated trade due to the porosity of the borders. While these areas may not be representative for the population at large, the information is nonetheless economically vital. Border prices with Guatemala are often lower than prices at large, with markups added as middlemen percolate commodities throughout the country. Conversely, tourists pay higher prices. While this can lead to higher profits, it can create other problems, not just pricing-out locals but also tourism-led economic phenomenon wherein the rapid development of one sector of the economy precipitates a decline in other sectors of the economy by making them less competitivef. This can happen when incumbent sectors are deprived of essential labour and capital resources as investments turn towards the new sector. It can also happen when appreciating currency increases export prices for incumbent sectors.

4.1.2 Wholesale and Intermediate input Prices

By far, wholesale and intermediary prices are the biggest missing piece amongst the current market-information systems. With these prices and several other ancillary components, SIB and/or MAFSE

would be able to compute a full-set of FD-ID price indices, including PPI, across multiple agri-food value chains. However, across all imports and any agri-food value chains where BMDC is present, the government is already capturing all this data. BCED has shipment-level information on almost every good brought into the country by a globally standardized index (HS Code) within a globally inter-operable system, ASCYUDA. BMDC has both quantities and prices for goods it is both importing and purchasing indigenously (e.g. buying remaining inventory from farmers). Furthermore, BMDC should have data for both intermediary inputs such as storage, transport, and packaging costs, and final outputs, that is the wholesale price to which it sells to retailers and other vendors. Given the size of BMDC and the leader-follower structure of most markets, it is likely the margins and costs of other wholesalers are quite similar. In fact, many wholesaler margins are already pre-set by price-control laws. The only information not currently being captured are wholesale prices of non-price-controlled agri-food commodities that are not in the business portfolio of either BMDC or the cooperatives audited by MAFSE's cooperatives department.

4.1.3 Agri-Inputs by commodity

The PPSIU department of MAFSE has done some preliminary work developing a per-acre/per-head list of agri-inputs per commodity and/or varietal. However, agri-inputs and associated quantities and prices is the second-largest missing piece. This is required to understand farms' unit-economics, farmer income, and produce FIPI indices. Agri-input subsidies with technical training are amongst the highest per-unit-value interventions in agriculture. This piece can readily be included into BAIMS existing surveillance. It requires the following effort:

- PPSIU to develop agri-input lists and Agri-input usage calendars by commodity and/or varietal and by acre/head for various agro-climactic zones of the country.
- SIB to include agri-commodity retail prices in their quarterly data-collection.
- The Cooperatives department of MAFSE to tabulate wholesale prices of various agri-inputs from the cooperatives they are already working with.
- BAIMS to include costs related to standard and unforeseen agri-inputs (pesticide, herbicide, veterinary, etc.) in their farmer surveillance questionnaire. To some extent BAIMS already does this.

4.1.4 Harvest and post-harvest costs

Once again the government Is already capturing much of this information within MAFSE's cooperatives department through their existing audit and engagement with cooperatives. It is not clear in what form this data exists, but the cooperatives department should have sufficient information to derive these harvest and post-harvest costs on a per commodity/per unit basis. BAIMS itself is not systematically capturing the cost of harvest, processing, and storage that the farmer, cooperative, or aggregator/wholesaler incurs in the first stage of production; however, it feasibly can.

4.1.5 Conversion factors from units to weight

Currently BAIMS often captures prices for items using counting units, for example the price of a single tomato. However, this is not a standard or comparable unit in anyway. PPSIU should at least on a seasonal basis tabulate the mean and standard deviation of such item-level commodities (e.g., mean and standard-deviation weight for a single tomato). Otherwise, this kind of counting data is not compatible with any of the other agri-food price information currently being collected. This information cannot for example be used to understand the retail-level markup for goods or compute FD-ID price indices.

4.1.6 Constraints on trade

While this may be ancillary market information, knowledge on constraints to trade can be invaluable. Underlying changes in primary inputs are not the only causal factor behind price changes. Packaging, storage, and transport can play an outsized roll. For example, for a brief time during COVID-19 egg prices in neighbouring Domenica skyrocketed due solely to egg-carton cost. Credit is another major factor as well. Credit is needed to smooth demand; hence a dearth of credit can result in wild price fluctuations especially when demand peaks coincide with supply-troughs. There is no unit within the government that is trying to systematically capture this information except for MAFSE to some extent through their engagement with cooperatives and farmers.

4.2 MARKET TREND/TONE

Systematically capturing information on the expectations of wholesale traders is a pre-requisite to accurate forecasts of price movements and supplies. Traders are often the closest to the source, and thus able to piece together frighteningly accurate market theses from the limited information they have. Currently there is not a mechanism by which the government can capture this information.

4.3 STANDARDIZATION & OVERSIGHT

Of the four major price-capture systems in place, commodities are coded in four separate ways:

- BCED's ASCYUDA system uses HS codes which are the global standard for classifying internationally traded commodities, sanctioned by the World Trade Organization and also used by the USDA.
- SIB's CPI app uses COICOP codes that are specific to household expenditures; however, they can be easily mapped to HS codes via Centralized Product Classification (CPC) *codes.* CPC codes are maintained by the United Nations Statistical Commission and is intended to be the international standard for organizing all trade, national accounts, and production information.
- BAIMS uses no international recognized coding system for agri-commodities.
- It seems reasonable to assume that BMDC also does not use a coding system, but very little information was obtained related to how they maintain their records.

Similarly, there is no harmonization amongst MAFSE or SIB on which agri-commodities are collected, how frequently, and using what unit of measure. This points to a broader issue of there not being a

lead unit within the government that can serve as a guidance and coordination body amongst various units in government that are collecting market information. Each unit operates independent of the other and acts in the best interest of the unit's own mission. However, in doing so, broader objectives and creative synergies may be lost and considerable effort is duplicated. A coordinating function or unit within the government could guide a holistic, big-picture approach to market monitoring systems.

4.4 INDICATORS & OUTPUTS

As mentioned earlier, the ability to produce FD-ID price indices especially across a wide array of economically important agri-food value chains—otherwise known as FIPI indices when produced at the farm-level—is the overarching standard to which the government should aspire to have its market-information systems. This would enable creating not only national PPI, but producer-price indices across value chains. However, there remain several indicators that can easily be computed in an automated, indexed, machine-readable manner with existing data held by SIB or MAFSE:

- **Price Indices for common agri-food commodities –** While SIB does decompose CPI into 13 COICOP categories, it should decompose this data into much finer divisions for specific agri-food commodity classes. They can also further decompose this data by geography.
- **Labour Terms of Trade –** This would be of fairly minimal effort for SIB but would produce a powerful indicator to firmly measure cost-of-living.
- **Price Forecasts & Early Warning –** With the combined data with SIB's CPI tool and BAIMS, the information is there to create fairly accurate hedonic price-forecasting models that can at least reveal when prices are starting to behave abnormally. Such an early warning system could be an invaluable policy tool for policy makers and practitioners.
- **Shock Impact and Simulation Modelling –** With the current CPI data, the household budget survey data, and labour data, SIB can and should implement a macro-economic shock impact and simulation modelling tool. WFP has already built such a tool that countries can easily deploy known as *Shock Impact Simulation Modeling (SISMod)* (World Food Programme - VAM, 2013). Such a system can provide ex-ante and ex-post quantitative information as to how vulnerable populations will be effected given sudden changes in price or supply.
- **Yield & Supply Forecasts –** While MAFSE is already doing this to some extent, it is not industrially scaled yet. The information is already there within BAIMS, including farm geo-coordinates for MAFSE to literally start producing customized, farmer-level prediction and insight at the farm level. Detailed agri-food commodity forecasts that can be dynamically overlaid via API with GIS and satellite data would allow MAFSE to provide pin-point precision intelligence to farmers.

4.5 DISSEMINATION

Dissemination is an area that the government can immediately improve on to strengthen its market monitoring. A missed opportunity for the government of Belize, and the hard-working men and

women within MAFSE and SIB, is that almost none of their monthly information is indexed and incorporated into global trade and economic information databases maintained by World Bank, FAOStat, Tridge.com, and others. Access to a global audience brings several potential benefits including increased export opportunities for agri-foods, possibly expanded global capital connectivity, and the attention of world-class researchers in agriculture, economics, and finance. Doing so would require going beyond publishing prices and values of indices into PDF documents and Microsoft Excel spreadsheets and just as readily provide data to other computer applications. This is arguably the biggest gap in dissemination of information from governments market monitoring systems.

Fortunately, the aforementioned issue is also the easiest gap to close, only requiring APIs to serve the relevant information in a machine-readable format known as JavaScript Object Notation language (JSON). The first step is to have the data well-organized within a relational database. This has already been completed for the most part, given that both BAIMS and SIB's CPI tool run on state-of-the-art databases. One must only ensure that the finalized outputs (prices, indices, etc.) are also respectively inserted into these databases. The second step is to instantiate a very light-weight server that can host the API and access the respective databases of SIB and/or BAIMS with appropriate security restrictions. Thereafter web applications and other computer-programs can request all the data they need through the API. Once API(s) are available many different dissemination applications can be built on top. Of particular importance would be:

- Easy access to known retail and farmgate prices via a phone-based messaging service
- Public access to projected crop yields and current inventories
- Public access to wholesale prices for various agri-food commodities by varietal

This data is the cornerstone upon which billions of dollars of agri-commodities are moved globally every day.

5. Recommendations

While this report takes an expansive view on identifying gaps, it is not within the scope to layout all actions required to close these gaps. Many of these gaps are already being addressed by the dedicated teams within MAFSE and SIB, and others may require an unrealistic level of resources. The report seeks to create a dialogue around the subject, therefore listed below is by no means a comprehensive list of recommendations, and focuses on those that were most readily apparent from key-interview discussions. Recommendations are ordered with respect to ease of implementation. The first two sections detail the most prescient recommendations, with the former focusing on those most straightforward to implement with few resources, while the latter section explores synergies that only arise if MAFSE and SIB begin to collaborate. Additionally, more resource-intensive recommendations, are offered in the subsequent section.

5.1 HIGH PRIORITY

A significant number of the issues mentioned previously can be addressed with a relatively low resources on the part of the government and the respective units involved while achieving outsized impact. These high-impact/low-resource recommendations are listed below (in order of ease of implementation) as a high priority.

MAFSE adopts an international standard for coding agri-food commodities. SIB already maps its data-collection to standardized codes for items. This mapping is internationally recognizable and connects all commodities to the HS index, also used by BCED's ASCYUDA system. However, the same is not true of MAFSE's data collection, which limits in interoperability. As a first order of priority, all data on agri-commodity items collected by BAIMS, BMDC, and other units under the purview of MAFSE should be mapped to either their standardized HS Code (also used by USDA) or their associated code in FAOCodex, a more granular system. This will at least allow data to be merged across SIB, MAFSE, and BCED.

MAFSE develops agri-input schedules for crops & livestock. This is vital information currently missing regarding agri-commodity production in the country. With these schedules and given agri-input prices, MAFSE would have the ability to estimate and forecast farmer income, devise and delineate more productive growing strategies, anticipate supply constraints, and forecast farmgate prices. Given the cost-of-living crisis it may also present an invaluable policy lever at a future point, such as through agricultural input subsidies, which are often a very cost-effective method to combat food-price inflation. Clear transparency and predictability over costs also encourages capital investment in agriculture and other long-horizon projects. Finally, *Farm Input Producer* (FIPI) indices can be computed from the data. This as a valuable barometer to measure the increase in agricultural productivity that a country's agricultural policy should produce over time.

A government unit is appointed as central coordinating body for all price data collection across the government. While it would be important to explore further the most appropriate

arrangements, the SIB is a logical choice for such a body, as it has a unique function almost exclusively producing data to be consumed by other units within the government and beyond. Hence it also has as bird's-eye-view of the data landscape, knowing where the data exists, whom to ask, and how it can be used. In this manner SIB unites three other critical functions that any coordinating body must possess:

- **High degree of technical advisory expertise** – Market information data collection can become a highly technical endeavour as this report elucidates. Great thought needs to be put into what data needs to be collected, how to connect to other data sources, and finally how to tabulate and produce meaningful information. This is SIB's domain as it has significant experience and expertise in this regard.
- **Ability to create highly valuable new analyses and data products** – Given access to data across the government and high technical expertise, SIB can also create additional value by coordinating and aligning price-data collection efforts. These products include producer-price indices, price forecasts, market alerts, and more.
- **Highly scalable information and data gathering systems** – This is arguably SIB's greatest single advantage. They have built a world-class market price information data collection tool that can be flexibly staffed with a bit of training. Much of their enumerator workforce is employed strictly on an as-needed basis, consequently their fixed costs are limited and can achieve efficiencies of scale. On a pure cost basis, SIB is well positioned to deliver market data collection at the lowest unit costs of any unit within the government.

MAFSE devises a process to regularly consume, process, and store price and volume data held by BMDC within BAIMS. BMDC has a treasure trove of information on intermediate prices and volumes for quite a few agri-commodity value chains. The fact that this data is not readily accessible is a tremendous missed opportunity. Most wholesale markets have a leader-follower system, where the biggest players set the trend and tone for the entire market, and mark-ups across the entire industry. With just BMDC's data and farmgate prices, MAFSE would be able to determine prices and costs along every step of the value chain from farm to fork across a wide range of agri-food commodities. SIB would have insight into ancillary costs to consumers arising from transport, storage, and packaging. These are not only of interest for developing FD-ID indices. Access to this information across a wide range of agri-food commodities encourages the entry of new traders and businesses, attracts investment, encourages market competition, and develops new export opportunities.

5.2 HARMONISATION OF EFFORTS BETWEEN MAFSE & SIB

Fundamentally, MAFSE's price data collections efforts duplicates efforts that SIB should ideally already be undertaking to accurately compute CPI. The most critical gap in SIB's CPI protocol is the exclusion of prices from open-air market vendors. While this data is collected by MAFSE, it does not have the rigour or standardization required by SIB. Likewise, SIB is not capturing data with the frequency required by MAFSE. This is a major opportunity to exponentially increase the impact and

capabilities of both organizations with a bit of alignment and investment of resources. In fact, savings from streamlined processes could potentially finance at least part of these recommendations.

RECOMMENDATIONS FOR STREAMLINING PROCESSES BETWEEN MAFSE AND SIB

Recommendation for MAFSE

Recommendation for SIB

Recommendation for MAFSE and SIB

1 SIB ASSUMES RETAIL PRICE MONITORING ACTIVITIES

RECOMMENDATION | Under the guidance of MAFSE, SIB to include any missing commodities from MAFSE's list and carry out price data collection from vendors operating in the country's major open-air markets

BENEFIT | Freed capacity of MAFSE's extension officers; Superior data produced for SIB and MAFSE

2 SIB UNDERTAKES WEEKLY DATA COLLECTION FOR OPEN-AIR MARKETS

RECOMMENDATION | SIB to collect data on food prices weekly instead of monthly; SIB to monitor 57 commodities on the MAFSE's list or, preferable, all foods on the combined list that can be easily purchased in such markets

BENEFIT | Satisfied MAFSE's requirement to monitor open-air food markets once per week

3 MAFSE FOCUSES ON HARVEST/PROCESSING COSTS AND FARMGATE/WHOLESALE PRICES

RECOMMENDATION | Farmgate prices already collected by MAFSE, however, harvest and post-harvest/processing costs are currently not collected but can be attained through the same farmer surveys MAFSE is already engaged in; MAFSE to incorporate data help from the Cooperatives department

BENEFIT | Data collected on harvest and post-harvest/processing costs

4 SIB COLLECTS MONTHLY AGRI-INPUT PRICES

RECOMMENDATION | SIB to collect monthly data on farmers' agri-input costs due to multiple cropping seasons and majority of farmers purchasing their inputs at retail prices (as the do not belong to cooperative)

BENEFIT | Data collected on farmers' agri-input costs

5 SIB REPORTS SUB-INDICES BY COMMODITY ITEM AND DISTRICT

RECOMMENDATION | SIB to use geometric Laspeyeres method to construct indices - the results need to be multiplied by the reference period's price to produce a representative price that can be consumed by buyers and sellers

BENEFIT | Representative price indices for farmers' agri-input costs

6 SIB AND MAFSE DEVELOP HIGH QUALITY APIs FOR BAIMS AND CPI SYSTEMS

RECOMMENDATION | As SIB and MAFSE will produce information required by the other party, both BAIMS and the CPI tool require robust interoperable APIs with the ability to serve processed data at the observation level or aggregated by district, item, time period, or all three

BENEFIT | Processed high quality data produced on the fly for both SIB and MAFSE needs

7 SIB AND MAFSE INVITE WORLD BANK AND FAOSTAT TO CONSUME DATA FROM APIs

RECOMMENDATION | SIB and MAFSE to make their data accessible via API to the World Bank and FAOSTAT in order to be consumed by every major financial institution, government, and agri-commodity company in the world

BENEFIT | Information disseminated globally

FIGURE 5. RECOMMENDATIONS FOR STREAMLINING PROCESSES BETWEEN MAFSE AND SIB (SOURCE: AUTHOR)

- **Both parties should come together to explore a model where SIB assumes retail price monitoring activities currently performed by MAFSE –** Given SIB's well-functioning, highly trained, highly scalable team and system in place for collecting price information, it can be a win-win for both parties if under the guidance of MAFSE, SIB simply includes any missing commodities (see Annex I) from MAFSE's list and commence price-data collection from vendors operating in the country's major open-air markets. This would free valuable capacity for MAFSE's extension officers while producing superior data for both SIB and MAFSE.
- **SIB undertakes weekly data collection for open air markets –** Currently SIB only collects food prices monthly. However, to satisfy MAFSE's requirement, the country's open-air food markets need be surveilled once per week. This can be limited to the 57 commodities on MAFSE's list; however, it is preferable if SIB surveils all foods on the combined list that can be easily purchased in such markets.
- **MAFSE focuses on harvest & processing costs, farm-gate & wholesale prices –** Freed of price-data collection responsibilities, MAFSE should focus on their comparative advantage with respect farmgate and wholesale prices. Farmgate prices are already being systematically collected insofar as possible. However, harvest and post-harvest/processing costs are currently not collected although they can be easily attained through the same farmer surveys MAFSE is already engaged in. MAFSE should also try to incorporate data help by the Cooperatives department, including wholesale prices and volumes for both ag-inputs and commodities and other processing and storage costs.
- **SIB additionally collects monthly agri-input prices** – Most farmers in the country do not belong to cooperative and thus purchase their inputs at retail prices. As there are three major cropping seasons in the country with potentially multiple fertilizer and pesticide applications per season, monthly data collection is a rational choice to arrive at farmers' agri-input costs.
- **SIB to report sub-indices by commodity-item and district –** This information is what MAFSE currently disseminates via its market monitoring activities and therefore needs to be replicated. However, geometric Laspeyeres is certainly the preferred method to construct these indices. The results need only be multiplied by the reference period's price to produce a representative price that can be consumed by shoppers and sellers alike.
- **SIB and MAFSE respectively develop high quality APIs for their BAIMS and CPI systems –** As SIB and MAFSE will be mutually producing information required by the other party, both BAIMS and the CPI tool require robust interoperable APIs with the ability to serve the finalized data at the observation level or aggregated to a specified level of granularity whether that be by district, item, time period, or all three.
- **SIB and MAFSE invite World Bank and FAOStat to consume data from their APIs** – To disseminate this information globally, SIB & MAFSE need only make their data accessible via

API to these two institutions. Once there, this information becomes part of the corpus of information consumed by every major financial institution, government, and agri-commodity firm in the world.

5.3 ADDITIONAL RECOMMENDATIONS

The additional recommendations below require more resources to implement. This may either be technical in nature, possibly needing training and resources from other third-parties, or monetary, requiring additional resources for personnel and data collection. This list is by no means all-inclusive and only expands upon suggestions from key-informant interviews.

5.3.1 Additional Data Collection

- **Wholesale trader surveys by SIB –** A quarterly survey of wholesalers across the most important commodity value chains in the country to understand their input prices, mark-ups, and (whole) sale prices could potentially be of great benefit. This also an important policy lever for the government, given that it already has a track record of controlling markups, a relevant policy-response to control inflation.
- **Producer surveys by SIB –** This is a necessary component for SIB to begin computing PPI. This is also necessary as a policy-lever for the same reason as above. Such a survey need only be quarterly.
- **Point of Sale data directly collected by SIB or BBS –** It is increasingly common for governments to request point-of-sale terminal data directly from selected retailers for certain commodities. This would greatly simplify the task of BBS (enforcement of markups and price controls) and SIB who would have a treasure trove of live price data to track prices.

5.3.2 Additional Indicators & Technical Recommendations

- **Move to Chain-Indices for CPI** – Chain-weighted CPI considers changes to consumer spending patterns over time. Given point of sale data, this begins to make sense as one can track expenditure patterns over time without new expenditure surveys.
- **Compute FD-ID/PPI indices –** If the recommendations of the previous two sections are put in place (High Priority & SIB-MAFSE harmonization), the SIB would have all it needs to compute these indices. Of particular importance are the FIPI indices for agriculture.

5.3.3 Personnel & Training

- **Additional personnel for SIB** – Many of the recommendations increase the footprint of SIB's responsibilities. To not only accomplish the aforementioned suggestions, but also build and implement new tools and analyses, at least one to two additional personnel are required.
- **Additional personnel for MAFSE –** A significant impediment for MAFSE to scale field data collection is the lack of dedicated *field-data* extension officers, meaning officers solely responsible for data collection. Additional personnel for data collection are needed in at least the most agriculturally active districts.

- **Training in R and/or Python for SIB & MAFSE –** Having data stored Excel spreadsheets, which are then coalesced to perform analyses also in Excel, is no longer tenable as data proliferates. The robust and long-term solution is to have data properly stored in databases, retrieved via API, and analyzed using a proper scientific programming tool such as R or Python. R is quite suited for SIB's mission due to its focus on econometrics and statistical techniques. Python is better suited for MAFSE due to its many modules for processing satellite imagery. Both units should invest in gaining a degree of proficiency using both languages.
- **Training in Shock Impact Simulation & Forecasting for SIB –** Shock impact simulation and forecasting allow SIB to build a host of data products off the current price data they are already generating. WFP has already built two such tools, SISMod and ALPS, that can be readily implemented by SIB if training is provided.
- **Training in Yield Forecasting with Satellite Imagery using Google Earth Engine for MAFSE –** Google Earth Engine allows a programming-light interface to build machine-learning models and produce summary statistics over satellite imagery. Such training would be ideal for MAFSE given their high technical expertise, though unfamiliar with scientific computing.

5.3.4 Technology & Equipment

- **BCED implements APIs for ASCYUDA –** UNCTAD has already developed an API module for ASYCUDA known as ASYHUB (ASCYUDA, 2022). It enables a standardized data integration platform between ASYCUDA and almost any external system. Implementation should simply be a matter of installation and configuration of the module.
- **Drones &training for SIB & MAFSE –** Both organizations, especially MAFSE, could make use of drones to increase the efficiency of their surveillance. For MAFSE drones enable extension officers to create precise geo-coordinated shape files of farms. This can be combined with satellite imagery to produce precise forecasts of yields or alerts of abnormalities at the farm-level. SIB could employ this system for wholesaler surveyors before market-days. Wholesalers generally arrive in trucks outside the market where they sell to retailers. However, there is no indication beforehand of where trucks selling a particular commodity will be stationed.
- **Additional vehicle(s) for SIB –** The lack of sufficient vehicles greatly hinders SIBs ability to do timely data collection. Even if enumerators have their own transport, a supervisor should be present at a district level. One or two motorbikes or a passenger vehicle would go a long way in alleviating this challenge.

5.3.5 Dissemination of data

Regional entities such as CARICOM can have a role to play as a convener of market price information from member states, to be disseminated at a regional level that ensures data is freely accessible for the public good. Consolidation and visualisation of the data from member states into a regional platform which presents data in a way that is functional for decision making can serve as an early

warning tool for price spikes alerts and promote market stabilisation. This is especially important in a region where supply chains are inherently sensitive and linked inter and intra-regionally. A complimentary bottom-up approach would see CARICOM, along with partners such as WFP, support individual member states in strengthening their market monitoring systems and tools. Cognizant that each CARICOM member states are at various maturity levels of their market price systems, an initial mapping process, such as this study can find entryways to boost the base level of member states to address data gaps throughout the value chain - from producers all the way to decision and policy makers. Opportunities to modernise processes and approaches that support innovation and should be prospected.

Conclusion

The Government of Belize has multiple market monitoring systems that are of high quality and staffed by dedicated and skilled experts. MAFSE has created a state-of-the-art agricultural monitoring system with BAIMS, and SIB's data-collection model is highly inventive by any measure. It is also fortuitous that such mutual synergies exist between the two units, with MAFSE collecting the very information that SIB is currently unable to collect for their CPI.

Broadly, there are two opportunities for strengthening market monitoring systems. The first is through harmonised efforts between SIB and MAFSE, wherein SIB incorporates MAFSE's current market monitoring into their efforts and enables MAFSE to focus on defining agri-input schedules, collecting harvesting and post-harvest costs, and finally farmgate and wholesale prices. With these changes in place, the government should have the necessary data to understand price transmission and cost structure across several major agri-food commodity value chains. The second is to improve existing systems both technologically and technically, using APIs to improve dissemination, new types of surveys to collect data, new methodologies to analyze data such as Google Earth Engine, and new information products such as FD-ID indices. Almost all the aforementioned recommendations can be accomplished without majorly significant investment in resources; however, the result dividends would be exponential, moving Belize to a best-in-class market monitoring system and seeding new opportunities in Belize's already vibrant agriculture sector.

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